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ABSTRACT

This packet consists of the instructor and trainee manuals for an asphalt raking course. The instructor manual contains a course schedule for 4 days of instruction, content outline, and instructor outline. The trainee manual is divided into five sections: safety, asphalt basics, placing methods, repair and patching, and clean-up and maintenance. Each section contains a list of objectives, a list of terms and definitions, and instructional/informative material. Appendixes include a glossary of terms and a list of aging asphalt mat blemishes and causes. (YLB)

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ED 379 417

ASPHALT RAKING

INSTRUCTOR MANUAL

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TRAINEE MANUAL

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Asphalt Course Schedule

Day I			AV Support Material
7:00	- 7:30	Orientation, registration	
7:30	- 8:30	Safety	*Heat Stress*
8:30	- 9:30	Asphalt Basics	
9:30	- 12:00	Placing Methods	*Rolling & Compaction of Asphalt Pavement* (sections I & II) *Rolling & Compaction III* *Jointing/Raking* L-AGC
12:30	- 1:00	Review hands-on and issue PPE	
1:00	- 5:30	In-field demonstrations of tools and equipment Begin sub-grade preparation for projects	

Day II

7:00	- 7:30	Review Homework
7:30	- 5:30	Continue sub-grade preparation and staking for projects.

Day III

7:00	- 7:30	Review Homework
7:30	- 5:30	Begin paving projects

Day IV

7:00	- 7:30	Review Homework
7:30	- 2:30	Complete paving projects
2:30	- 5:30	Clean-up, complete evaluations, issue certificates.

Asphalt Raking Manual Design Outline

I: Safety

a. Protective Clothing
   - i. gloves with elastic cuffs
   - ii. pants with no cuffs
   - ii. long sleeve shirts
   - iv. flat sole work boots
   - v. hard hats
   - vi. personal appearance
   - vii. safety glasses
   - viii. safety vest (reflective)

b. Heat Stress/Exhaustion (audio visual support)
   - i. causes/environment
   - ii. symptoms
   - iii. prevention
   - iv. treatment/response

c. Skin Reactions
   - i. description of solvents likely to be encountered
   - ii. description of symptoms
   - iii. prevention
   - iv. treatment

d. Burns
   - i. likely heat sources
   - ii. prevention
   - iii. treatment

e. Physical Hazards
   - i. jewelry/loose clothing
   - ii. equipment awareness
   - iii. escape routes
   - iv. lifting techniques

II: Asphalt Basics

a. Description of Asphalt
   i. petroleum residue
   ii. uses of asphaltic cement

b. Mix Design
   i. asphalt plants
   ii. aggregates in asphaltic concrete
   iii. mix types for drives
   iv. mix types for highways
   v. cold mix

c. Hand Tools
   i. shovels
   ii. lutes
   iii. rake
   iv. torch
   v. spray can
   vi. hand tamper
   vii. straight edge
   ix. putty knife
   x. blocks and shims
   xi. depth guage
   xii. pick or mattock
   xiii. 5 gallon bucket w/ swab
   xiv. push brooms
   xv. ruler/tape measure
   xvi. spray paint
   xvii. smoothing iron

d. Equipment Descriptions (audio visual support)
   i. plate compactors
   ii. walk behind compactors
   iii. vibratory, static, and pneumatic rollers
   iv. gab
   v. box paver
   vi. paving machine
   vii. trucks (end dumps, floboys, belly dumps)
   viii. pick up machine
   ix. planing machines (hot or cold)

e. Crew Responsibilities
   i. screed person
   ii. rakers
   iii. shovelers/dump person
   iv. flag persons
   v. operator
   vi. roller operator
   vii. responsibilities to show up and on time

III: Placing Methods

a. Subgrade Preparation
   i. compact, clean, and ongrade
   ii. check joints for full depth

b. Lay Out
   i. setting strings
   ii. marking radii

c. Tack and Primer Application
   i. description of prime application
   ii. description of tack application
   iii. description fabric application

d. Asphalt Quantities
   i. sample quantity calculations
   ii. using asphalt calculators

e. Jointing Methods (audio visual support)
   i. transverse joints
   ii. longitudinal joints
   iii. stack joints
   iv. feather joints
   v. paper joints
   vi. joint repair procedure

f. Hand Spreading
   i. dumping techniques (signalling)
   ii. shoveling techniques (broadcasting)
   iii. raking techniques

g. Compaction
   i. hand tamper
   ii. vibratory plate
   iii. walk-behind
   iv. rollers

IV: Repair & Patching

a. Potholes
   i. preparation
   ii. repair

b. Skin Patches
   i. preparation
   ii. application

V: Clean-up & Maintenance

a. Housekeeping
   - i. solvents
   - ii. excess mix
   - iii. debris (stringlines, paper, etc.)

b. Keeping Tools Clean and Maintained
   - i. by temperature
   - ii. by solvents
   - iii. maintaining defective tools

c. Keeping Equipment Clean
   - i. end of shift clean-up

Instructor Outline
Classroom - 5 hours

Section I

1. Discuss Terms and Definitions on page 2 in Trainee Manual.
2. Stress the importance of the use of PPE listed on page 3.
3. Discuss heat stress, causes, symptoms and prevention.
4. Discuss health hazards from fumes and chemicals and routes of exposure.
5. Describe other hazards on paving projects and how to avoid accidents from these hazards.

Section II

1. Discuss Terms and Definitions on page 12 in manual.
2. Discuss asphalt properties and uses in the paving industry.
3. Describe asphalt mix materials and different mixtures. Talk about mixing processes and mixing temperatures.
4. Identify hand tools used by asphalt paving crews and uses of different tools and equipment.
5. Identify paving equipment and the use of each different type.
6. Discuss crew responsibilities - Stress teamwork.

Section III

1. Discuss Terms and Definitions on page 22 in manual.
2. Discuss importance of a good subgrade to maintain a good asphalt pavement. Work through the layers of subgrade from the lower layers up to the pavement.
3. Describe methods used to layout and mark areas for paving.
4. Talk about prime coats and tack coats. Review the types of asphalt materials used and application methods.
5. Calculate asphalt quantities as described on pages 27-29 in trainee manual. Estimate quantities for class projects.
6. Learn in detain the different joints and jointing methods. Joints are a rakers most important job and raking techniques must be acquired.

ASPHALT RAKING

TRAINEE MANUAL

Laborers-AGC Education and Training Fund
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Section I: Safety

Page	2	Terms and Definitions
Page	3	Protective Equipment and Clothing
Pages	4 - 5	Heat Stress
Pages	5 - 7	Health Hazards from Fumes and Chemicals
Pages	7 - 8	Other Hazards
Page	9	First Aid for Molten Asphalt Burns

Trainee Section Objectives

1. To become aware of protective clothing for working with asphalt.
2. To become aware of the potential for heat stress/exhaustion when working on a paving crew.
3. To become aware of possible health hazards from hazardous fumes and chemicals.
4. To become aware of other hazards that are likely to occur on a paving project.
5. To learn First Aid techniques for molten asphalt cement burns.

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Terms and Definitions

Acclimated	To accustom or become accustomed to a new environment or situation.
Dermatitis	Inflammation of the skin.
Local Effect	Affecting or pertaining only to a particular place or area.
Systemic Effect	Affecting or pertaining to the entire body.
Acute Effects	An adverse effect on a human or animal body, with severe symptoms developing rapidly and coming quickly to a crisis.
Chronic Effects	An adverse effect on a human or animal body, with symptoms which develop slowly over a long period of time or which recur frequently.

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Protective Equipment and Clothing

Protective clothing on an asphalt project is very important. Asphalt is normally placed at temperatures between 250° and 320° F. This is much hotter than boiling water. If asphalt touches your skin at these temperatures, severe burns will result.

You can prevent or reduce the severity of burns by wearing the right type of clothing to work. The list below depicts some of the items that may save you from getting burned on a paving project.

Long Sleeve Shirt - A long sleeve shirt constructed of heavy material may prevent your arms from being burned by falling particles of hot asphalt.

Gloves With Elastic Cuffs - Gloves with tight fitting cuffs can prevent hot asphalt from falling into your gloves and burning your wrists or hands.

Cuff-less Pants - Do not wear pants with cuffs in them. Cuffs make a place for asphalt to get caught in and burn you.

Hard Hat - As with all types of construction projects, hard hats are a must. A hard hat may prevent you from being struck on the head by falling or flying objects such as a shovel full of hot asphalt or the shovel itself.

Work Boots - A good quality work boot will make working around hot asphalt much easier on your feet. Buy boots with flat soles, these will not pick up asphalt as readily as textured soles and will be easier to clean.

Other personal protective equipment and clothing may be:

Safety Glasses - Your eyes are important to you, do not allow them to get damaged on the job. Get safety glasses from your contractor and wear them.

Ear Plugs - Do not sacrifice your hearing on a project. Get earplugs and wear them when the noise is intense.

Respirators - Be aware of the type of solvents and materials you are working with. Check the Material Safety Data Sheets for references to hazardous fumes. If you are working with solvents or other materials that may be giving off fumes, get a respirator of the type approved for the fumes you are working with from your contractor and wear it whenever necessary.

Safety Vest - Paving projects are almost always going to be close to vehicle traffic. Get a high visibility safety vest and wear it whenever working around vehicle traffic.

General - Do not wear work clothes with holes in them, you want to prevent any contact between your skin and the asphalt.

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Heat Stress

Heat stress is a major physical hazard on an asphalt paving project. The chance of developing heat stress increases with increased humidity, hot environments, and the use of personal protective equipment.

Sweating is the most effective means of losing excess heat, as long as adequate fluids are taken in to replace the sweat.

When individuals are severely stressed by the heat, they may stop sweating with the most severe consequences of heat stress occurring. Adequate rest periods, availability of large amounts of replacement fluids, and frequent monitoring are essential to prevent the consequences of heat stress which may occur without warning symptoms.

The body maintains a normal temperature in a hot environment by two methods:

- Sending more blood to the skin
- Sweating

As the temperature in the air increases, sweat production allows more heat to be carried away through evaporation from your skin. As the humidity in the air increases or if the sweat can't be removed from the skin because of protective clothing, the body has more difficulty keeping an acceptable safe temperature.

The body also cools by sending more blood to the skin. This reduces the blood available for the brain and muscles. Therefore, people who work in hot environments may feel tired sooner and less mentally alert.

Both these factors may contribute to increased accidents on a project.

TABLE 1-1: SIGNS AND SYMPTOMS OF HEAT STRESS

The three primary concerns from working in hot environments are:	
Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:	• Muscle spasms • Pain in the hands, arms, feet, legs, and abdomen
Heat exhaustion occurs from increased stress on various body organs, and the blood circulation system and is due to the inability of the heart to work properly and/or dehydration. Signs and symptoms include:	• Pale, cool, moist skin • Heavy sweating • Dizziness • Nausea • Fainting • Rapid, shallow breathing
Heat stroke is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are:	• Dizziness and confusion • Nausea • Strong, rapid pulse • Coma • Red, hot, usually dry skin • Lack of, or reduced perspiration

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Early stages of heat stress can cause rash (prickly heat), cramps or muscle spasms, irritability, discomfort and drowsiness. Advanced stages can cause nausea, dizziness or weakness, confusion, collapse, convulsions, coma and death. Individuals who survive the most advanced stages (heat stroke) are likely to have damage to the brain and other organs. Heat stroke is a serious, life threatening medical emergency. It can happen in just a few minutes of extreme heat conditions.

Individuals at particular risk of heat stress.

- Workers wearing protective clothing.
- Workers who are dehydrated from blood pressure medications or infections such as diarrhea or fever.
- Workers who are not physically fit or have not worked in a hot environment in the preceding week (become acclimated).
- Workers with chronic disease such as heart disease or diabetes.
- Workers who drink excessive alcohol or use drugs.
- Workers who are very overweight.
- Workers who regularly take certain medications for depression, nervous conditions, high blood pressure, diabetes or heart disease.

Preventing Heat Stress

1. Drink adequate amounts of fluids (water or juices) throughout the day, even if you are not thirsty. The amount should be 4-6 liters (1 to 1.5 gallons). Alcohol, coffee, soda and tea are not good fluids to replace water lost during sweating.
2. Maintain good physical fitness. Individuals should work cautiously until their body has adjusted (become acclimatized) to the heat.
3. Recognize the signs and symptoms of heat stress.
4. Monitor pulse, temperature and weight.
5. Check with your doctor if you have chronic health problems, or are taking medication.

Note: Taking salt tablets to replace salt lost when sweating is **not** recommended. A normal diet contains more than adequate amounts of salt.

Health Hazards From Fumes and Chemicals

Many chemicals used on a paving project can damage the body. Effects range from skin irritation and dermatitis, to chronic diseases such as cancer of the liver and blood. The body may be harmed at the point where a chemical touches or enters it. We call this a local effect. When the chemical benzene, used in a number of solvents and fuels such as diesel fuel, touches the skin it can cause drying and irritation (local effect).

A systemic effect develops at some place other than the point of contact. Benzene can be absorbed through the skin, breathed into the lungs or swallowed (ingested). Once in the body, benzene can affect the bone marrow, leading to anemia and leukemia. Leukemia is a kind of cancer affecting the bone marrow and blood. When inhaled, solvent

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vapors enter the blood stream and travel to other parts of the body, particularly the nervous system. Most solvents have a narcotic effect. This means they affect the nervous system by causing dizziness, headaches, feelings of "drunkenness," and tiredness. One result of these symptoms may be poor coordination which can contribute to falls and other accidents on the construction site.

It may take years of exposure to a chemical to produce harm, or harm can occur in a matter of minutes. When these effects happen quickly, the chemical is said to have acute effects. If the harmful effects take a long time, they are called chronic effects. Thus, always be aware that many of the materials you use or handle are potentially dangerous, both right away and in the long term.

Routes of Exposure

The three major routes of exposure to chemicals used in construction are inhalation, ingestion, and skin absorption. Inhalation is breathing into the lungs and respiratory system dusts, fumes, vapors, and gases. Ingestion is eating or swallowing dusts and other small particles. The other major route of exposure is skin absorption.

Skin Absorption

The skin is the largest organ of the body, covering about 19 square feet of surface area. It is often the first barrier to come in contact with hazardous contaminants. The skin must protect you from heat, cold, moisture, radiation, bacteria, fungus, and penetrating objects.

Upon contact of a substance with the skin, five actions are possible:

1) The skin and the layer of fat cells can act as an effective barrier against penetration, injury, or other forms of irritation.

2) The substance can react with the skin surface and cause a primary irritation (dermatitis).

3) The substance can penetrate the skin and accumulate in the tissue, resulting in allergic reactions (skin sensitization).

4) The substance can penetrate the skin, enter the bloodstream, and act as a poison to other body parts (systemic action).

5) The substance can penetrate the skin, dissolve the fatty tissues, and allow other substances to penetrate the skin layers.

Most job-related skin conditions are caused by repeated contact with irritants such as solvents, soaps, detergents, dusts, oils, grease, and metal working fluids. This is called contact dermatitis and the symptoms are red, itchy skin, swelling, ulcers, and blisters. The length of exposure and the strength of the irritant will affect how sever of the reaction as well as abrasions, sores, and cuts, which opens a pathway through the skin and into the body.

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Compounds that are good solvents for asphalt, such as gasoline, diesel fuel and lighter fluid, may cause problems by being readily absorbed through the skin. Abrasions, lacerations, and cuts may greatly increase the absorption, thus increasing the exposure to toxic chemicals.

Fumes

Fumes are solid particles in the air. They are usually formed when metals are heated to their melting points, especially during welding or soldering.
Although many fumes can irritate the skin and eyes, these fine particles primarily affect the body when they are inhaled. This type of exposure sometimes results in an acute effect, referred to as "metal fume fever" especially if the fumes are from metals such as zinc, cadmium, or magnesium. Fumes may also be produced by the heating of asphalt during hot tar roofing or road paving. These fumes are a suspected carcinogen (can cause cancer). The American Conference of Governmental Industrial Hygienists has established a maximum allowable exposure amount

You, the worker, should avoid breathing the vapors whenever possible. Normally, the more you are exposed to a hazardous material, the more likely you are of developing adverse health effects.

Vapors

Vapors are gaseous forms of certain materials that are usually solid or liquid at room temperatures. Vapors may be formed when liquids or solids are heated. Some materials, such as solvents, form vapors without being heated. Solvent vapors are one of the most common exposures on a construction site. Gasoline or diesel fuel give off fumes at temperatures normally encountered on a paving job.

Both vapors and the materials from which they evaporate can harm the body. Many directly affect the skin causing dermatitis, while some can be absorbed through the skin. As with gases and fumes, most vapors when breathed pass to the blood stream and damage other parts of the body.

Other Hazards

Accidents occurring on paving projects can be avoided by developing an awareness of the hazards and hazard causing occurrences. You can prevent these accidents by not allowing the causes of accidents to occur.

Loose clothing is a good example. Avoid wearing clothing that may get tangled in the moving parts of the machinery you are working around.

Be aware of where the equipment is working around you at all times. Do not get so absorbed in your task that you forget where the asphalt equipment is at.

Do not turn your back on trucks and cars. If you must work close to vehicle traffic, have a flagperson who's attention is focused on the traffic work with you.

Plan an escape route ahead of time. Think about how you are going to

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get out of the way of the trucks and cars should one of them loose control.

The most common accident in the construction industry are back injuries. Almost always it is from lifting a load that is too heavy or from lifting the load wrong.

Do not make the mistake of assuming that back injuries are caused from a single lift. Common back disorders are more likely to be caused by improper lifts performed over a period of time. Lifting the wrong way day after day will increase your chances of injury even though you don't feel any pain at the time.

Think about the following lifting techniques when you have to move something heavy.

- Test the load first, if it is too heavy, get someone to help you or move it with a piece of lifting equipment.
- Plan each lift, check the area to make sure there is room and a clear path for carrying and placing the load.
- Place one foot behind the object and one alongside.
- Keep your back straight.
- Tuck your chin, so the head and neck continue the straight back line.
- Get a firm grip with the palms of your hands. Your palms are stronger than your fingers.
- Keep the object close to you, with your arms and elbows tucked in the sides of your body. This will keep your body weight centered.
- Lift straight and do not try to swivel your back to turn the object. If you have to change directions, pivot your feet instead of twisting your back.

FIRST AID FOR MOLTEN ASPHALT CEMENT BURNS

In the event of a molten asphalt cement burn:

Cool The Asphalt Cement And Affected Parts Of The Body Immediately.

Methods of cooling (in order of preference):

1. Completely submerge affected area in ice water;
2. Completely submerge affected area in tap water;
3. Place affected area under running water.

Use any available water, cooler that body temperature, while arranging for better cooling.

Caution: DO NOT apply ice directly to affected area. Leave the cooled asphalt cement on affected area.

For minor asphalt cement burns - get victim to a physician at the first opportunity.

Minor asphalt cement burns include:

Injury to small areas of fairly insensitive flesh involving a small quantity of asphalt cement.

For serious asphalt cement burns - get victim to a hospital, clinic, or physicians office as soon as possible.

Serious asphalt cement burns include:

Injury to the head, face or extremities;
Injury when large amounts of asphalt cement are involved;
Evidence of nausea or faintness.

DO NOT ATTEMPT TO REMOVE THE ASPHALT CEMENT WITH PRODUCTS CONTAINING SOLVENTS OR AMMONIA.

Natural separation will occur in about 48-72 hours. If necessary, for early removal, soak bandage in mineral oil and place over affected area for 2 to 3 hours.

TREATMENT FOR SHOCK

In the event shock occurs, do the following:

1. Keep victim lying down and quiet.
2. Keep victim covered with a blanket or something similar to keep body temperature at normal, 98° (37°C).
3. Keep victim's head lower than feet to promote blood supply to head and chest.

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Section II: Asphalt Basics

Page	12	Terms and Definitions
Pages	13 - 15	Asphalt Properties, Uses, and Mix Design.
Page	16	Hand Tools in Paving Operations
Pages	17 - 19	Equipment Used in Paving Operations
Page	20	Asphalt Crew Responsibilities

Trainee Section Objectives

1. To learn the following terms and definitions.

   a. Aggregate
   b. Asphalt
   c. Bitumens
   d. Cutback
   e. Emulsion
   f. Prime coat
   g. Pugmill
   h. Sieve
   i. Tack
   j. Viscosity

2. Become aware of asphalt properties and uses.

3. To understand common asphalt mixing processes and design for varying uses.

4. To competently identify asphalt hand tools.

5. To competently identify common asphalt equipment.

6. To understand common asphalt crew responsibilities.

Terms and Definitions

Aggregate - Composed of a mixture of minerals separable by mechanical means. In trade language, aggregate means the mixture of different sized particles into a graded mixture of rock and smaller particles.

Asphalt - A brownish-black solid or semi-solid mixture of bitumens obtained from native deposits or as a petroleum by-product, used primarily in paving, roofing, and waterproofing.

Bitumens - Any of various mixtures of hydrocarbons and other substances, occurring naturally or obtained by distillation from coal or petrouleum.

Cutback - Trade language for asphalt mixed with a petroleum solvent. Intended to liquify asphalt for spray or mixing applications.

Emulsion - A suspension of small globules of one liquid in a second liquid with which the first will not mix, such as asphalt in water.

Prime coat - Trade language meaning a coat of liquid asphalt sprayed onto the base or lower layer. Designed to seal out water and to provide a bonding surface for the newly placed asphalt.

Pugmill - A heated kettle or rotating drum at an asphalt plant. Used to heat and mix aggregate and asphalt.

Sieve - A utensil of wire mesh or closely perforated metal used for sifting or straining. In trade language, a sieve is a screen used in separating material from an aggregate sample by material size.

Tack - Trade language for liquid asphalt emulsion or liquid asphalt. Usually applied to surfaces that will need bonding with fresh pavement such as manholes and other utilities, curbs, and existing asphalt in patching and jointing operations.

Viscosity - The degree to which a fluid resists flow under an applied force. In trade language, viscosity refers to how easily an asphalt semi-solid or liquid will flow.

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Asphalt Properties and Uses

Asphalt is a cementious material, dark brown to black in color and can be solid, semi-solid, or liquid in consistency. Practically all asphalt used today is derived from the refinement of crude petroleum.

Asphalt is being used for many purposes in the industrial, building, and paving industries. The list below shows some of the more common uses:

- Road Paving
- Roofing
- Tires
- Water-Proofing
- Expansion and Roofing Felt
- Floor Tiles
- Pipe Coatings
- Battery Cases
- Protective Undercoatings

Asphalt In The Paving Industry

Asphalt at ordinary temperatures (below approximately 100° F) is a solid or semi-solid. For use in the paving industry it must be changed to a liquid. This is accomplished in three different ways:

1. by heating, as in a heating kettle or storage tank.
2. by dissolving in a petroleum solvent (commonly called a "cutback").
3. by combination with water (called "emulsion").

Early in the twentieth century a standardization of asphalt grades was begun. This standardization specified the differing grades of asphalt using a testing procedure called a "penetration test". The penetration test measured the depth a weighted needle would penetrate a sample under standard conditions (77° F). In mid-century, a more fundamental test called "viscosity" began to be used to specify the desired consistency ranges. Viscosity grades are designated by the prefix "AC- followed by a number that indicates the viscosity of the material. In the 1970's, an additional viscosity grading system was developed, based on a testing system called the "rolling thin film oven test". The grades in this system are designated by the prefix "AR-" followed by a number indicating the viscosity of the material.

In the penetration grading system, the higher the grade number the less viscous (softer) the asphalt. In the viscosity grading systems the higher the grade number the more viscous (harder) the asphalt.

Asphalts that are liquefied by blending with petroleum solvents are generally referred to as "cutbacks". When mixed with solvents and spread on a road the solvent will evaporate leaving the asphalt cement behind as a coating or paving surface. These asphalts are made in different types that will provide a different evaporation period. Rapid Curing (RC) contains a gasoline or naptha (lighter fluid) type solvent that will evaporate quickly. Medium Curing (MC) contains a solvent similar to kerosene or # 2 diesel and will allow for a longer evaporation period than RC. Slow Curing (SC) asphalt is not usually called a cutback because it's solvent is not added but left in during the refining process. The SC type also is sometimes referred to as "road oil".

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Each curing type can be provided with four viscosity (hardness) controlled grades. These grades range from Grade 70, which contains the most solvent and is the most fluid, to Grade 3000, which contains the least solvent and is the least fluid. Also a special grade called MC-30 is included in the medium curing type and is used almost exclusively for prime coating (base course surface preparation before paving) and dust control.

Asphalt emulsion is a liquid mixture that contains asphalt cement, water and an emulsifying agent. In an asphalt emulsion, tiny droplets of asphalt are suspended in water. These droplets "break" or come out of suspension over time and coat the surface where they have been applied. They are referred to as Rapid Setting (RS), Medium-Setting (MS), and Slow-setting (SS) depending on the amount of time to break out of suspension. Asphalt emulsion will appear brown in color while the droplets are still suspended and will appear black once the water and asphalt separate.

About Aggregates and Asphalt

Most paving mixtures contain a graded aggregate that is coated with liquid asphalt in a heated mixing drum. This aggregate is usually specified in the project documents to contain certain amounts of different sized particles. The reason for specifying the various amounts of particles is to decrease the possibilities of voids or holes in the asphalt and to provide a smooth finished mat. For example, Table 2-1 depicts the percentage by weight a sample of common street paving mix would consist of.

Table 2-1: Common Paving Mixture

Sieve Sizes	Percentage Passing
3/4"	100 %
3/8"	67 - 85 %
1/4"	50 - 65 %
No. 8 Mesh	37 -50 %
No. 30 Mesh	15 - 25 %
No. 200 Mesh	3 - 8 %

Plus 50/60 penetration liquid asphalt at 5% to 6-1/2% of the dry aggregate weight.

The mesh number mentioned in Table 2-1 is a series of screens called "sieves".

The sieves are graded according to the number of openings per square inch. For example, a No. 8 sieve has 8 openings per square inch a No. 30 has 30 openings per square inch and so on. These sieves are used to determine the amount of weight in a sample that passes to the next sieve. For example, the table indicates that 100 % of the sample must pass the 3/4" screen and 3 - 8 % of the sample must pass the No. 200 sieve.

Asphalt Paving Mixtures

Asphalt paving mixtures vary with the type of application. For example the type of asphalt and aggregate used on the face of an earth fill dam will be different than the type of asphalt and aggregate used for a runway at an airport. The project documents will indicate which type of asphalt and the aggregate mix proportions to be used.

Other asphalts used on the project will be specified in the project documents as well. For example, a common paving tactic is to coat the paving surface with what is called a "prime coat" before paving. The prime coat is usually an asphalt cutback type, such as MC-30 or

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MC-250. The purpose of this is to seal the underlying layer and provide a bonding surface for the new asphalt to adhere to.
Another common paving tactic involves the use of what is called "tack". Tack is usually a liquid asphalt emulsion. It is used to provide a "sticky" bond between existing objects and the new asphalt.

A common use for tack is on the edges of curbs and manholes or on existing edges of asphalt during patching or jointing. Similar to the paving asphalt and the prime coat the type of asphalt emulsion to be used for tack will be specified in the contract documents. A common liquid emulsion for use in city streets would be a slow setting (SS -1) type.

Asphalt Mixing Processes

As you have read above, asphalt paving mixes are designed to rigid standards. Standards indicating what type of aggregate; what type of asphalt; and how much of each; are enforced on a project by testing and sampling the asphalt during the paving procedure. If the asphalt fails to meet the contract specifications the project owner has the right to force the contractor to remove all sub-standard asphalt from the project and pave it again with the right mix.

Most asphalt will be mixed at a plant specifically designed to mix asphalt. The mixing process is started by heating the aggregate and asphalt separately until both reach around 250° to 325°F (121° to 163° C). Once heated, measured proportions of aggregate and liquid asphalt will be mixed in a heated drum commonly called a "pugmill" until each particle in the aggregate is coated with the liquid asphalt. The hot mixture is then placed in trucks for delivery to the project site.

Almost all paving projects have a maximum and minimum temperature designed for the asphalt mix to be paved. Too hot and the asphalt will burn, too cold and the asphalt will not compact properly and will retain too many voids. A common mixing and placing temperature would be 290°-325° F maximum leaving the plant and 280° F minimum at the time of placing. These maximum and minimum temperatures will vary with the specific mix type and design.

Other types of asphalt do not have to be mixed at a plant. Commonly called "road mix" they are asphalt emulsion or cutbacks in liquid form mixed into aggregate existing on the project site and rolled in place. This type of paving eliminates the need of a central mixing plant and will utilize the existing project aggregate.

Other types of asphalt paving materials and asphalt mixes are listed in the appendices of this manual.

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Hand Tools Used In Paving

The most common hand tools used in an asphalt paving project are the shovel and lute. The shovels (Fig. 2-1) can be short handled or long handled and are used to carry and clean-up asphalt. Lutes and rakes (Fig. 2-2) are used to smooth and spread asphalt into a uniform graded surface

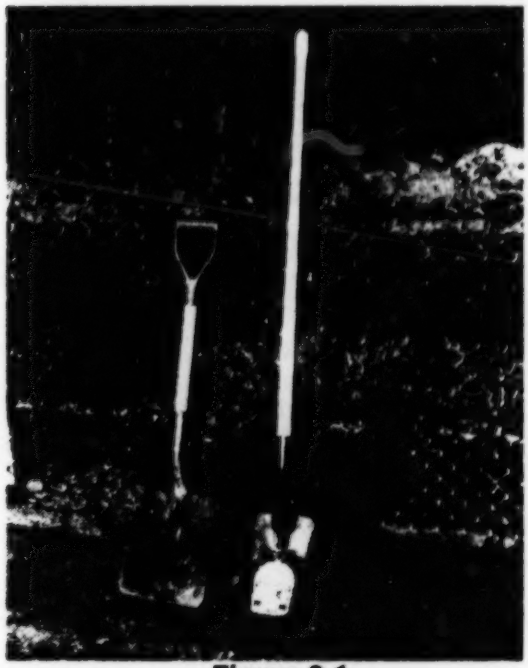

Figure 2-1
Common shovels used in paving projects.

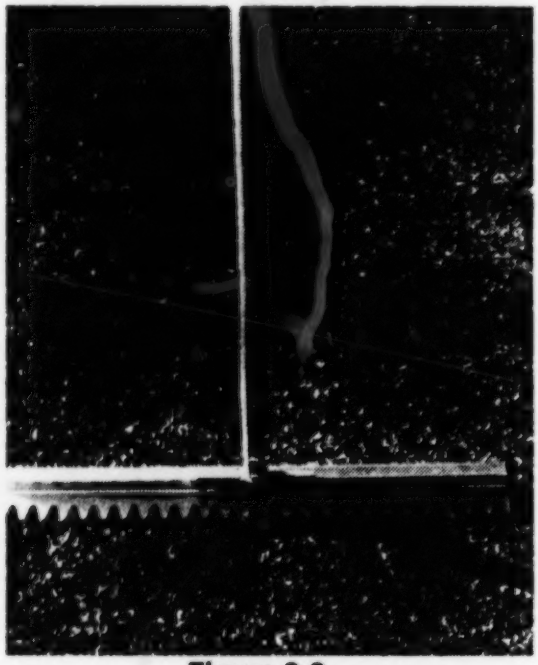

Figure 2-2
Asphalt lute

and to build smooth joints. Hand tampers (Fig. 2-3) are used to compact asphalt wherever a larger pavement roller or compactor can not be used.

Other tools that may be used are listed in Table 2-2.

Table 2-2: Common Tools Used in Paving Operations

Tool	Purpose
torch	warm asphalt into a workable state
spray paint	used to mark paving lines and limits
straight edge	used to check for irregularities in the paving
putty knife	used to clean other tools
depth guage	used to check asphalt placement depth
pick or mattock	used to clean edges of joints and patches
5 gallon bucket	used to store solvent for cleaning tools
push brooms	used to clean surfaces before paving
smoothing iron	used to smooth rough edges

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Figure 2-3

Hand tamper used for asphalt compaction in areas where rollers or other compactors can not be used.

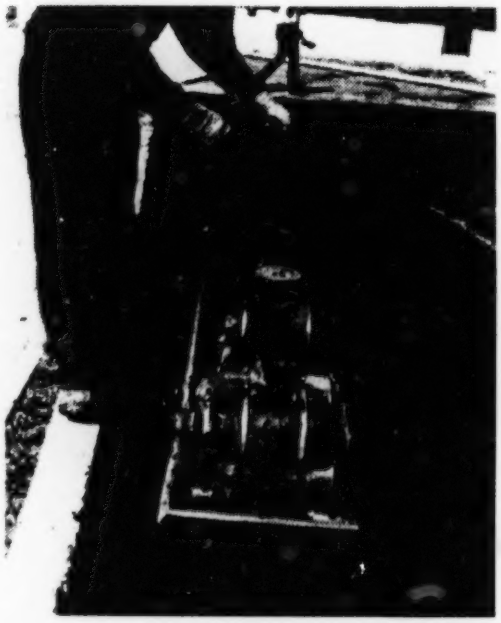

Figure 2-4
Plate compactor

Equipment Used in Paving Applications

The type of equipment used in paving operations depends on the type of project. Most projects will use small compactors such a plate compactor or a walk-behind compactor (Fig. 2-4). Larger projects will need larger compactors such as rollers and pneumatic tire rollers (Fig. 2-5 & Fig. 2-6).

Figure 2-5
Steel drum roller

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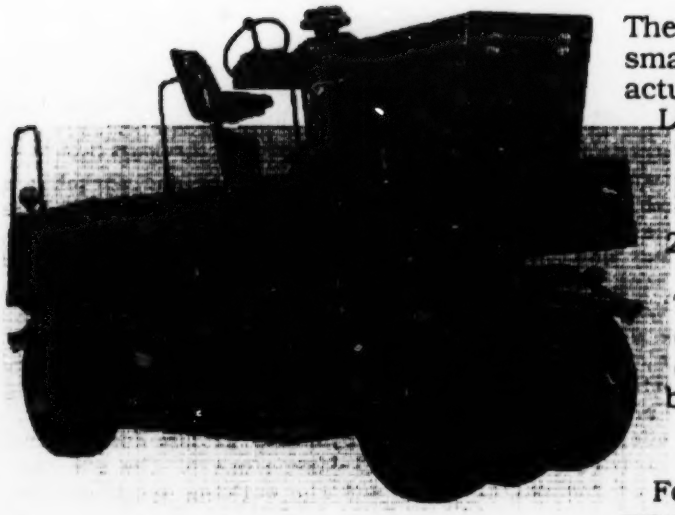

Figure 2-6
Rubber tire roller

The pavers used can vary from smaller box pavers where the truck actually pulls the paver such as the Layton Box depicted in Fig. 2-7, to large paving machines that push the trucks along. Such as the Barber-Greene shown in Fig. 2-8 on the next page.

The type of trucks that will deliver the hot asphalt are dependant on the type of paver being used on the project.

For example, a small project would likely use a Layton Box and end dump trucks as depicted in Fig. 2-7. A large project may include some additional equipment to keep the paving going at a steady pace, such as a low lift material loader as shown in Fig. 2-9. When using a loader or "pick-up machine" the mix must be dumped into a windrow (usally with belly dumps) and quantities must be calculated closely so not too much or too little is dumped

Figure 2-7
Layton Box Paver

Other types of equipment used in paving or in paving support operations are trim machines. Trim machines are used to grind upper layers of existing asphalt to provide room and an even surface for asphalt overlay projects. Other uses include placing and/or trimming the final course of aggregate base or asphalt treated base to an accurate grade in preparation for paving (shown in Fig. 2-10).

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Figure 2-8
Barber-Greene paving machine receiving hot mix from a floboy truck

Figure 2-9
Low lift loader being used to load the paver hopper from a windrow.

Figure 2-10
CMI modified full-width grade trimmer placing base course.

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Asphalt Crew Responsibilities

Depending on the project type and size an asphalt crew normally consists of four to 8 individuals. The specific responsibilities of these individuals for a normal project are listed below:

The Shovelers - The shovelers are responsible for assisting the rakers in all situations. They will carry asphalt back from the paving hopper and place it at the direction of the rakers. When not working with low lift loader equipment, they should watch for asphalt that has fallen in front of the paver. This asphalt has to be moved away from the tracks to prevent the paver from climbing onto the piles and leaving a rise in the freshly placed mat. The shovelers will aslo watch and correct track marks in the subgrade to insure that the paver is not running over humps or dips.

The Rakers - The asphalt rakers are responsible for insuring smooth joints both longitudinal (lengthwise) and transverse (crosswise). They will work with the shovelers to level and grade areas that can not be paved with the paving machine. They are often responsible for checking and correcting drainage areas to make sure that no ridges or dips are paved in these areas that will stop or hold water.

The Screed Man - The screed strikes off, partially compacts, and irons the surface of the asphalt as it is being laid. The screed man will use the screed to adjust the depth of the mat and will operate what is called the "wings" on the paver. The wings are hydraulic or mechanically operated extensions of the paver. These allow the paving machine to widen or narrow the width of the mat. The screed man will work closely with the shovelers and rakers to insure that the wings are kept full of asphalt (when used) and that the mat is being laid at the correct depth.

The Paver Operator - On self-propelled paving machines, an operator is needed to keep the paver going in the right direction and at the correct speed. The paver operator will also help to signal trucks into and away from the paver.

The Roller Operator - On projects that are using rollers for compaction, there will be from one to three roller operators. Usually there is a "breakdown" roller, an "intermediate" roller and a "finish" roller. Whether these rollers are operated by one, two, or three operators depends on the project type and size. Since asphalt is harder to work with once it has been rolled, the breakdown roller operator will work very closely with the rakers to insure that joints are raked and compacted correctly.

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Section III: Placing Methods

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Pages	24 - 25	Common Marking and Layout Techniques
Page	26 - 27	Application of Prime and Tack Coats
Page	27	Asphalt Payment Methods
Pages	27 - 29	Asphalt Quantity Calculations
Pages	30 - 32	Common Jointing Methods

Trainee Section Objectives

1. To learn the following terms and definitions:

a.	Sub-grade	b.	Borrow
c.	Mainline	d.	Fillets
e.	Radii	f.	Screed
g.	Approaches	h.	Intersections
i.	Radius Point	j.	Transverse
k.	Longitudinal	l.	Pass
m.	Mat		

2. To become aware of the importance of proper sub-grade preparation.
3. To learn common layout and asphalt limit marking methods.
4. To learn common methods of prime coat and tack applications.
5. To become aware of common methods of payment for asphalt paving projects.
6. To competently calculate asphalt quantities.
6. To become competent at raking the various types of joints.
7. To become competent at hand spreading and raking of asphalt.
8. To become aware of the importance and methods of asphalt compactions.

Terms and Definition

Approach	-	A trade term referring to a driveway or other small road connected to the main street allowing vehicles access to the main street.
Borrow	-	A trade term referring to structural material used to construct a road. Called borrow usually because the project owner makes the material available to the contractor.
Fillets	-	A trade term referring to the usually triangular area formed between a main street and approach or intersection.
Intersection	-	An intersection is the area where two streets cross or intersect.
Longitudinal	-	An trade term meaning parallel to the direction of travel.
Mainline	-	A trade term referring to the main street in a paving contract, also can be used to indicate a straight or long section of paving on a project.
Mat	-	The term used to indicate the asphalt being placed by a paver.
Pass	-	A term used to refer to a single movement of a paver or roller before starting over or changing direction.
Radii	-	In intersections and approaches, the arc that contacts the straight edge of paving on one street and contacts the straight edge of paving on the adjacent street.
Radius Point	-	In intersections and approaches, the position that is the same distance from the straight edge of paving on one street and the same distance from the straight edge of paving on the adjacent street.
Screed	-	A trade term that refers to the usually heated iron on a paving machine. The screed will level and smooth the asphalt as it leaves the paver.
Sub-grade	-	A trade term referring to the aggregate material levels underlying the asphalt.
Transverse	-	A trade term referring to perpendicular to the direction of travel.

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Sub-grade Preparation

The importance of proper preparation of the layers of material underlying the asphalt can not be stressed enough. This preparation should account for three items:

1) The type of materials below the asphalt.

2) The compaction of the materials below the asphalt.

3) The drainage of the materials below the asphalt.

The type of materials below the finished paving layer will affect the strength and durability of the asphalt. Without the proper support below, the asphalt will settle and crack under the weight of vehicle traffic.

The materials below a finished asphalt surface are usually constructed in layers. The contract documents will specify the proper percentage of particle sizes by weight in a sample of each underlying layer. Figure 3-1 depicts a standard cross section for a rural street. Note the differing specifications for the material layers. These layers will be increasingly specialized as they get closer to the finish asphalt paving.

To explain the material requirements of each of these layers we will begin with the bottom layer called "Usable Excavation and/or Borrow".

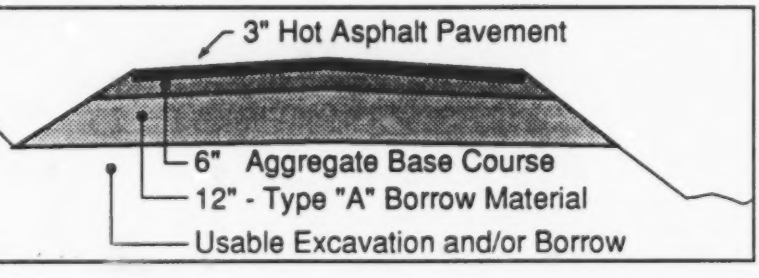
The specifications for the **usable excavation** layer will allow most of the material from excavations on other portions of the project, exceptions to this would be organic material such as tree stumps, limbs, roots, or peat. Organic materials are not allowed in road sections because they will rot and leave voids in the fill. If there is no usable excavation on the project then the contract specifies the use of borrow material in this layer.

The next layer up is specified as a "**Type A Borrow Material**". The "Type A" means that the contract documents provide a name for the material and they will specify the maximum size of the rocks and the amount of different sized particles by weight. Usually material in this layer is 6" minus (all rocks must fit through a 6" by 6" screen) and can contain no clay or organic material.

The last layer before asphalt is specified in the cross section as "**Aggregate Base Course**". The aggregate base course is a screened crushed material usually consisting of 3/4" minus rock mixed with the various percentages of smaller sized particles. This material is graded to provide a smooth, dense layer that will prevent water from moving through it and provide a smooth base for the paving.

Compaction of these underlying levels is extremely important. Not enough compaction will allow settlement of the materials causing cracks and depressions in the road surface. The contract documents will specify the amount of compaction to be attained on each of these layers and they will be field tested during the construction process. The lower levels of usable material and type A borrow are usually specified to attain a minimum of 95% compaction, whereas the aggregate base course will usually be specified to attain a minimum of 98%.

Figure 3-1
Sample cross section of a typical rural street specifying the different material layers to be constructed below the asphalt.



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As you can tell by these specifications, the contractor should be constantly aware of the status of the compaction efforts on each of these levels. By the time the aggregate is placed, it is too late to make up for compaction deficiencies in the lower levels.

The drainage of the underlying levels and the surrounding area is of critical importance. Water in or close to a road is not good. It will soften the underlying layers and create soft spots that will not provide the needed support for the asphalt and allow it to break. If the project is in an area that freezes during winter, it is even more important to prevent water from being in or around the asphalt. Water expands when it freezes causing frost heaves that will break the asphalt surface.

Water standing on the surface of asphalt can also lead to failure of the asphalt as well as cause hydroplaning or sliding of vehicles. For this reason a paving crew will be very careful to insure that water runs off the pavement into the designed ditches or curb inlets. However, the paving crew can not make large adjustments to the project to account for drainage.

Asphalt currently costs between $25.00 and $40.00 a ton. At these prices the profit and loss margin for a contractor is much smaller than the cost of additional asphalt needed to make a project drain correctly. The project drainage must be built into each level with increasing accuracy as it approaches the finish paving. The aggregate base course level should be carefully examined by the project inspector as well as the paving crew to insure that it is shaped correctly to allow for drainage and that extra asphalt is not needed to make the water flow.

The secret to good pavement is in the subgrade. It must consist of materials that will hold up the traffic that runs on it. It must be compact, and it must drain.

Common Marking and Asphalt Layout Techniques

Before the paving can actually begin the asphalt crew must know what the limits of paving are. The crew must plan the width of each pass needed to pave the entire width and place each pass at that width.

For mainline paving, stringlines can be set on centerline or the shoulder of highway and the operator will follow the string while checking the width of the mat being laid. Most paving machines are customized with an adjustable guide the operator can line up on the string and follow to insure a straight pass.

The shovelers or rakers usually lay the stringline guide ahead of the paver. If the road is small and the paver will cover one side in one pass, the string can be set directly on centerline. Usually the grading crew that placed the base course will have left some hubs or stakes indicating the centerline of highway. The rakers or shovelers will stretch the string out ahead of the paver, line it up to insure that it will guide the paver in a straight line and place small piles on it to secure it in place. Larger paving operations can employ a stringline set on either side of the paver that will provide the automatic paver with screed control as well as alignment control.

Marking Radii and Fillets

The layout of radii and fillets for intersections and approaches can be done with string or with spray paint. Spray paint is easy to follow and provides the operator or rakers with a good guide for following the curve. Figure 3-2 depicts a standard intersection with the fillet area shaded and the radius point and radius distance indicated.

To mark the fillet shown in Figure 3-2, Locate the radius point and measure the designed radius distance. Holding the tape tight and close to the ground, spray a paint line while you swing from where the radius distance touches the mainline pass to the

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other mainline pass. Approaches can be marked using the same techniques. If the approach is angled to the mainline the outside radius will be longer than the inside radius. Regardless of the angle of the approach, the radius point will still locate the beginning and end of the fillet. Figure 3-3 shows an angled approach.

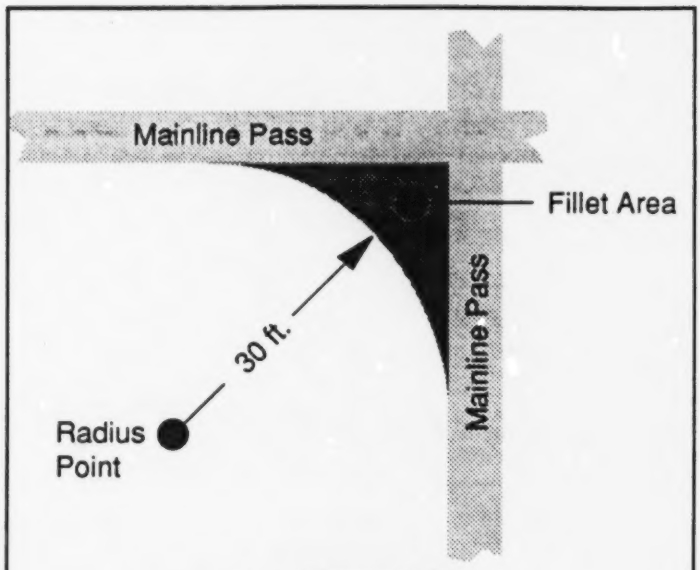

Figure 3-2
The dark shaded area shows a paving fillet. The limits of the fillet can be marked using a rag tape and can of spray paint.

Application Methods for Prime Coats and Tack Coats

Prime Coats

The application of a prime coat between the aggregate base course and new asphalt is designed to accomplish several purposes:

- Waterproof the surface of the base.
- Reduce capillary (very small) voids in the surface.
- Coat and bond loose particles to the aggregate surface.
- Harden and toughen the surface.
- Promote adhesion between the base and the overlying asphalt course.

As was mentioned earlier in this manual, water is asphalt's worst enemy. The application of a prime coat on the aggregate base course will provide one more layer of waterproofing for the surface. By sealing the very small voids called "capillary voids", the prime coat will prevent water from moving through the underlying levels to the surface.

The next most important reason for a prime coat application is to provide an adhesion or bond between the aggregate base and the overlying asphalt mat. Without this bond the forces applied from traffic may cause the asphalt to break and slide.

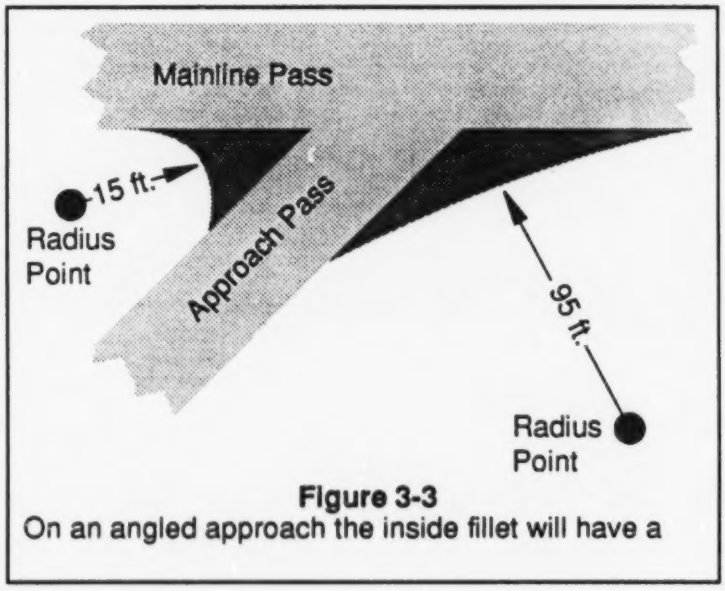

Figure 3-3
On an angled approach the inside fillet will have a

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The type of asphalt normally used for prime coating are a medium-cure cutback such as MC-30 or MC-70 (see appendix for asphalt types and uses). The application of cutback asphalt is normally done by a distributor truck such as is shown in Figure 3-4. The contract documents will often direct the amount of liquid asphalt to be applied by gallons per square yard. The prime coat should be applied evenly with complete coverage.

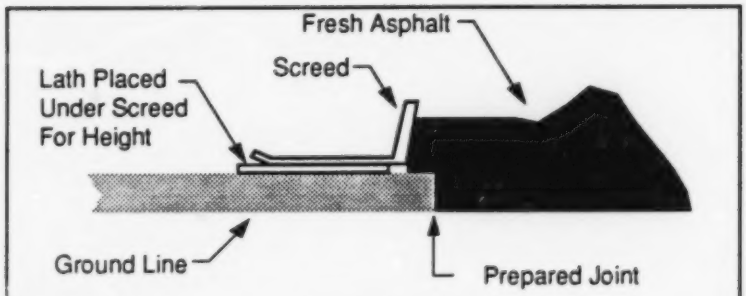

Figure 3-4
Constructing a transverse joint against an existing mat. The lath are placed under the screed to allow enough depth to account for compaction of the new mat.

Tack Coats

Tack coats are designed to provide an adhesive bond from the underlying levels to the freshly placed asphalt. They are applied on all vertical and horizontal surfaces that will have new asphalt against them. They should be applied in a very thin and very even layer.

Vertical surfaces include curbs, utlities in the street such as manholes/valve covers and existing asphalt joints.

The type of asphalt most often specified for use as a tack coat will be a liquid asphalt emulsion, usually a Slow-Set type such as a SS-1 (see appendix for asphalt types and uses).

Once again, the contract documents will usually specify the type and amount of asphalt emulsion to be applied by gallons per square yard.

The tack coat will be applied by distributor truck for larger applications and applied by hand in smaller areas. Often the contractor will have a hand sprayer unit for tack application, if not, a normal house broom cut off close to the bristle binding area and a bucket of tack will work for small applications.

In applications of tack coat that use liquid asphalt emulsion, the tack coat should be applied early enough to allow the asphalt to come out of suspension before paving.

During the application of tack, **be sure** not to place it on areas that are not designed to have new asphalt on it or against it, for example, the gutter area in a curb. As was mentioned earlier, the tack coat forms an adhesive bond, the new asphalt will stick to whatever has had tack applied to it. In fact, one method most asphalt rakers will use to make a straight joint will be to make sure the tack is applied in a straight line where they want the joint to begin.

Asphalt Payment Methods

The basic unit of measurement of asphalt is the ton. The asphalt item in a road contract is usually estimated by either the ton or by the square yard. This difference in item payment will affect how the contractor prefers to pave the project.

By the Ton

If the contract has specified that asphalt will be paid by the ton installed, the contractor will want to pave as close to the maximum tonnage allowed in the contract as possible.

By the Square Yard

If the contract has specified that the asphalt will be paid by the square yard completed, the contractor will usually prefer to pave as close to the minimum tonnage allowed in

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the contract as possible.The difference between the two types of payment are as follows:

- If the contractor is producing or purcasing the asphalt for a less cost than is being paid for under the contract, then every ton is making money. Under a pave by the ton contract, the contractor is usually allowed a 10-15 % overrun amount. This 10-15% can turn into a considerable amount of money on a large project.

- If the contractor bid the project by the square yard, then every extra ton of asphalt used is coming out of the project profit. The contractor will almost always prefer to pave the minimum amount.

Asphalt Quantity Calculations

The first step for caclulating quantities of asphalt is to work with the same unit of measurement. Since asphalt is normally estimated and sold by the ton we will need to calculate the volume that one ton of asphalt will cover.

Common asphalt paving mix will weigh approximately 145 pounds per cubic foot. Based on 145 lbs. per cubic foot, one ton of asphalt will occupy a volume of 13.79 cubic feet.

We arrived at this volume by dividing 2000 lbs. (one ton) by 145 lbs. (weight per cubic foot)

2000÷145= 13.79 cu. ft. per ton

By The Square Foot
Based on the fact that one ton will pave 13.79 cubic feet, we can determine approximately how many square feet or square yards this amount will pave at several different paving depths.

At 2" deep
If our paving depth is 2" (expressed as 0.17 decimal feet) we can divide 13.79 by .17 to determine how many square feet one ton will cover.

13.79÷.17= 81.14 square feet

At 4" deep
If our paving depth is 4" we would divide the 13.79 cubic foot amount by the decimal equivalent of 4" or 0.33.

13.79÷.33= 41.79 square feet

By The Square Yard
Since projects are often bid by the square yard we will need to know the amount of asphalt (by the ton) required to pave a square yard at different depths. We have already established that one ton will pave approximately 81 square feet at 2" thick.

At 2" deep
If we divide the 81 square feet by 9 (there is 9 square feet in one square yard) we can establish that one ton of asphalt will pave 9 square yards at two inches deep.

81.14÷9= 9.02 square yards

At 4" deep
To calculate the amount of square yards covered by one ton of asphalt at 4" deep we can use the same procedure.

41.79÷9= 4.64 square yards

Calculating the tons required for a project can be accomplished using the coverage rates we have just discussed. The first step is to check the weight per cubic foot of the designed asphalt. If the asphalt weighs 145 lbs. per cubic foot (the weight we used previously) our previous calculations will be accurate. The next step is to measure the project and express the area in either square feet or square yards.

By Square Feet
For example, if our project was 24 feet wide and 600 feet long, we would multiply 24 times 600 to calculate the surface area.

24x600= 14,400 square feet

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We have already calculated how many square feet one ton of asphalt will pave at different paving depths so we can divide that amount into the total area as is shown below.

At 2" deep

14,400÷81.14= 177.47 Ton

At 4" deep

14,400÷41.79= 344.58 Ton

By Square Yard

Using the same project width and length we can express the surface area in square yards as easily as square feet. Since there is 9 square feet in a square yard we can divide the total square footage by 9 to express the area as square yards.

At 2" deep

14,400÷9= 1,600 square yards
1,600÷9.02= 177.38 Ton Required

At 4" deep

14,400÷9= 1,600 square yards
1,600÷4.64= 344.83 Ton Required

There is some difference in the amounts calculated using each of these methods. This difference is due to rounding of the decimal. In practice, round to the nearest whole ton.

Example Exercise

What would be the tons required for the same project (24x600) if the paving depth is 3"?

(Use 145 lbs./ cubic foot.)

Common Jointing Methods

Asphalt joints are areas where one pass connects to either existing asphalt or to structures in or by the new paving such as manholes and curbs. They can be called "hot joints" or "cold joints". A hot joint is when the joining area of 2 asphalt passes are both at sufficient temperature to allow the joint to be compacted as if it was placed on the same pass. A cold joint is required after the asphalt has been compacted. Even if the asphalt is still hot, jointing against any compacted asphalt is considered a cold joint.

The quality of joints on a project can affect the quality of the entire project.

Most asphalt against asphalt paving joints can be grouped into two categories:

- Tranverse Joints
- Longitudinal Joints

Transverse joints are joints that have to be constructed across a paving lane, or 90° to the direction of vehicle travel. Some examples of transverse joints would be where a new paving project meets existing asphalt or where a joint must be constructed due to the end of a shift (night joint).

The first factor to consider when constructing a transverse joint is compaction. Asphalt will normally shrink 10-20% of its freshly placed depth when it is compacted. The asphalt raker must check to insure that this extra amount is placed either by the paver or is placed by hand at the joint.

Once the paving machine pulls away from the joint, the raker will push the extra material back to the joint and separate larger aggregate out of the joint area. Once the larger aggregate has been separated and only the fines remain, the raker will stack the material at the edge of the existing mat high enough to allow for compaction.

Once the joint itself is raked and before the compactor begins, the raker should also check for dips or humps caused by the screed adjusting to the proper depth at the beginning of the pass.

An over or under loaded screed may cause a rise or dip at the beginning of the pass or until the screed has evened out with a steady load. The raker can check for this with a straightedge or by eye. Figure 3-5 depicts a dip during take-off. The raker must fix

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these problems immediately. After they have been compacted is too late.

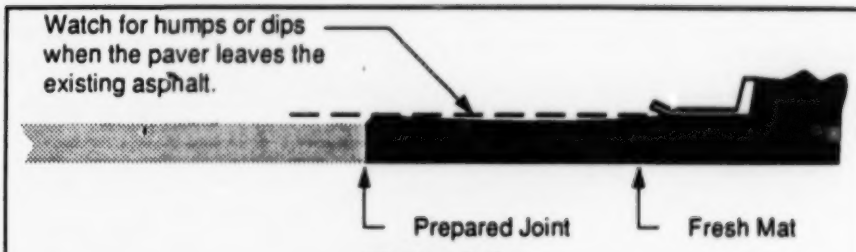

Figure 3-5
The raker will check the area following the joint to correct any dips or humps caused by the screed riding up or down during the takeoff.

Night Joints

Constructing a night joint can be accomplished several ways. A method called the "paper joint" uses a piece of paper that is coated on one side (such as butcher paper) to prevent a tapered section of asphalt from adhering to the base or underlying layer. The purpose is to construct a full depth edge that can be tacked and paved against at the beginning of the next shift. A tapered wedge of asphalt placed on the paper will allow the rollers to complete each pass without reducing the paving depth at the planned joint location. Figure 3-6 depicts two types of night joints, one is a paper joint and the other is constructed using a piece of lumber to form the edge. At the beginning of the next shift the tapered asphalt and the lumber or paper can be removed to leave a straight line and a vertical face to pave against.

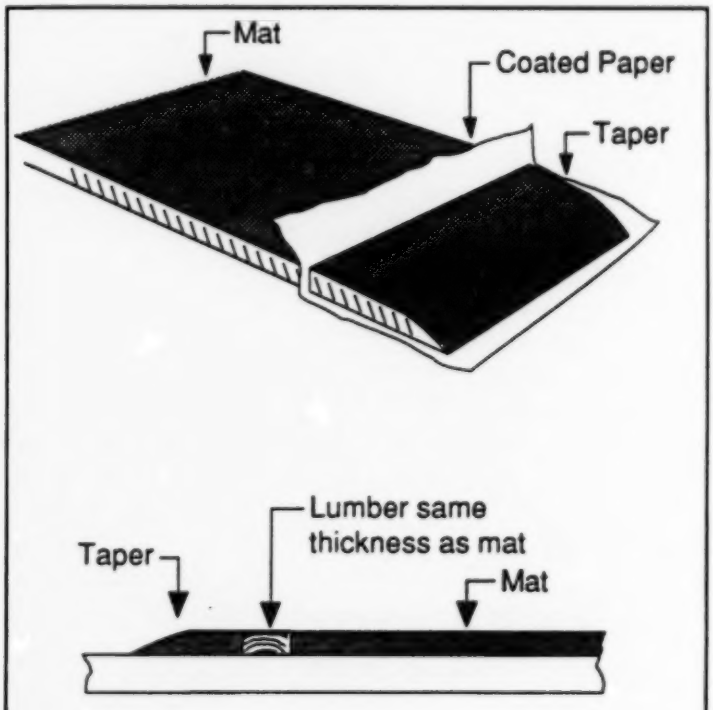

Figure 3-6
A night joint can be constructed using a coated paper to prevent the new asphalt from adhering to the underlying material or by paving up to a piece of lumber laid across the lane and raking in a taper for the roller to leave the mat

Longitudinal Joints

Longitudinal joints are formed when a second pass is paved alongside the first pass. The first lane paved should leave as straight an edge as possible to make the next pass easier to pave against. The length of the passes can determine what kind of joint will be needed between the paving passes. For example, a common paving tactic is to not compact the last 6-12" on the

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side adjacent to the next pass. The paver will stop and back into the 2nd pass before the 1st pass cools. This is referred to as a "hot joint". The advantage of a hot joint is the asphalt from both passes at the joint will compact evenly and will not usually leave a distinct joint line.

To rake a hot joint all you need to do is make sure the depth of both passes is close to the same. Only rake a hot joint when there is a noticable difference in the depth of the two passes.

If it is not possible to use a hot joint on the longitudinal joint, a cold joint will be necessary. To rake a cold joint, cut the extra material from the compacted mat by bringing a rake full of the asphalt back to you, then briskly push it onto the hot mat with an upward or lifting stroke. This will drop the smaller aggregate or "fines" out into the joint and distribute the larger aggregate or "bones" onto the hot mat. The joint should be left high enough to account for compation and with no fresh asphalt on the compacted pass as shown in Figure 3-7.

Leveling Wedges

When preparing for a re-surfacing operation, wheel ruts or excessive crown situations can be corrected by using "leveling wedges". Leveling wedges are a layer(s) of asphalt used to level depressions or to correct an excessive crown situation. Wedges will vary in thickness and may be "feathered" into each side. Leveling wedges thicker that 3" should be placed in a series of compacted lifts. When placing multipole layered wedges the shortest wedge should be placed first and successive layers should extend past the feathered edges. The asphalt used for leveling wedges usually uses a fine graded mix to allow for feathering without the screed crushing the larger aggregate or riding up on them. If large aggregate are present the raker will have to remove them form the feathered joint with a lute to leave a smoothly tapered joint.

Hand Spreading

When dumping asphalt for hand spreading it should be placed far enough ahead of the shovelers so the entire pile must be moved and the workers will not have to stand on the pile. A signalman should have the driver dump small batches and move out of the way. This will allow faster spreading of the pile so it doesn't cool too much and rakers can keep up with the shovelers. Do not attempt to spread asphalt when shoveling as this will completely segregate the mix. Deposit the material from the shovel in small piles and spread the piles with lutes. If any of the mix from the bottom of the pile doesn't loosen thoroughly during spreading the lumps should be discarded.

After raking the hand spread mix, check the surface with a straightedge and level all the low or high spots before compacting.

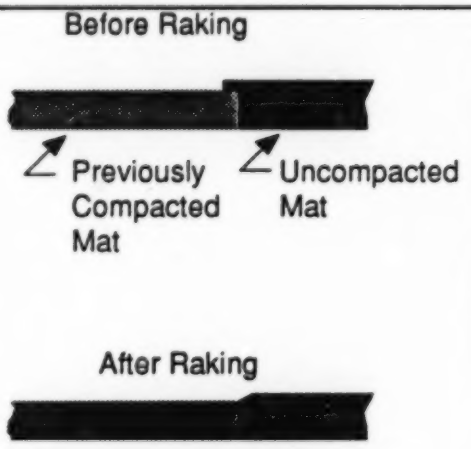

Figure 3-7
To rake a cold joint, trim the extra asphalt from the compacted mat and briskly push the extra material onto the hot mat with a lifting stroke. Leave the fresh mat high enough to account for compaction.

Compaction

Hot mix asphalt has 3 components; aggregate, asphalt cement and air voids. Aggregates used in pavement should be crushed and have rough surfaces so they bind together and provide stability. Asphalt cement binds the aggregate particles together after they have been compacted. At paving temperatures the asphalt cement acts as a lubricating fluid and as it cools becomes a glue-like binder. Air voids or the spaces not filled by aggregate or asphalt cement make up about 15% of the volume of the hot mix as it comes from the paver.

Compaction of hot mix asphalt must reduce air voids to 5% or less to increase mat stability and provide a smooth riding surface and extended pavement life. Good compaction of the mat is possible only if two conditions exist; confinement of the mix and the correct mix temperature. Confinement means the mix is held in place from all directions so that the aggregate are packed together to reduce air voids. Confinement from the bottom comes from the road base.

This reminds us of the importance of a well compacted subgrade and the need of a prime coat. Confinement from the top comes from roller contact with the surface of the mat and confinement from the sides comes internally from the surrounding mix being compacted. For the surrounding mix to resist flow and not shove out instead of compacting the asphalt cement must be in the correct temperature range. Different mixes have different temperature ranges for proper compaction. Most mixes must be compacted before the drop below 185° F.

When using rollers for compaction a good pattern will give the best uniformity and efficiency needed to meet density requirements and maintain production. If the mat has an unsupported edge, that is, an edge that is not against a curb or another mat the first pass should be about one foot from the unsupported edge, then roll. This pattern will allow the least amount of shoving as the first pass will help support the weight of the roller during the fourth pass.

Joints are critical areas that often lack good compaction. With cooperation between the paver operator, the rakers, and the roller operator a good joint will result. When rolling a longitudinal joint with a static steel drum roller, keep most of the roller on the cold mat and overlap the hot mat by six inches. If a vibratory roller is being used keep most of the roller on the hot mat,. To compact a transverse joint the roller is set up to straddle the joint, with most of the roller on the cold mat. As rolling continues gradually overlap each pass until the roller is completely on the hot mat. Boards should be used at the edges of the mat to allow the roller to run off the mat. Transverse joints should be rolled without vibration.

Areas to be paved that are too small for rollers must be compacted with hand tampers and small vibratory plate compactors. Small areas are usually spread by hand which allows the mix to cool rapidly. The use of hand tampers or vibratory plate compactors must follow placement immediately for good compaction.

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Section IV
Repair and Patching

Alligator Cracks

These are cracks forming small blocks resembling alligator skin or chicken wire. This type of cracking is usually caused by surface deflection of the pavement due to an unstable subgrade. The unstable subgrade can be caused by saturation of the granular base material or overloading the capacity of the pavement.

Potholes

Potholes are a result of pavement disintegration or the breaking up of a pavement into loose fragments. Potholes are caused by weak pavement with too little asphalt, failure of the road base or from saturated subgrades.

Permanent repair of potholes and alligator cracks require a deep patch to restore the pavement surface. A deep patch repair should be constructed using the following procedure:

1. Before removing any material the area to be repaired should be sawed to provide a vertical face. The saw cut should extend a minimum of 1' outside the cracked area. When sawing, make the cut square or rectangular with two cuts at right angles to the direction of traffic.

2. Remove the damaged pavement tot he saw cuts. Remove enough base material to reach firm support. Be sure to keep the sides of the repair vertical. If the excavation is more than 6" deep, base material should be compacted in layers to reach the depth of the asphalt pavement.

3. Apply tack to all vertical surfaces. If the full-depth repair is made using asphalt mix no prime is needed. If granular base is used it should be primed and the repair made with hot asphalt surfacing material and compacted to match the surrounding pavement. Large repairs should be checked with a straightedge for proper alignment.

Skin Patches

A skin patch may be required to repair slight grade depressions caused by grade settlement, pavement overloading or poor compaction of the pavement. This type of repair returns the pavement to the desired grade without removing the old pavement or subgrade.

Determine the limits of the patch area using a straightedge or stringline and mark with a crayon or paint. Clean the area to be patched with compressed air to remove all dust and moisture. Apply a light tack coat of asphalt emulsion and allow the tack to cure.

Fill the desired area with enough hot asphalt material to return to the original grade when compacted. When raking the edges, remove the coarse aggregate to allow the edges of the patch to be feathered with the finer material. Check the raked material with a straightedge to be sure of a smooth repair and thoroughly compact the patch with a vibratory plate compactor or a roller.

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Section V
Clean-up and Maintenance

On asphalt paving jobs solvents are used for cleaning tools and equipment. The most common solvent is diesel fuel. Some pavers have a solvent tank mounted on the side for shovels and rakes when not being used. Also solvent is used in 5 gallon buckets for cleaning shovels, lutes and rakes during paving operations. Care must be taken not to spill solvent on the asphalt surface or on the subgrade as this will cause deterioration of the pavement. Used solvent should be stored in a 55 gallon drum to be recycled or for proper disposal.

When raking joints excess coarse aggregate is usually removed and discarded alongside the pavement. Night joint tapers (transverse joint made at the end of a shift) must be removed and discarded each day to begin paving operations. This excess mix must be picked up to keep the jobsite clean and prevent contamination. Load the excess mix onto trucks returning to the asphalt mixing plant for recycling.

Other debris on paving jobsites should be cleaned up as the project progresses. Stringlines used to maintain straight lanes are usually twine and are not reused. Paper used for transverse joints must be discarded. Lumber used to allow the roller onto the pavement to roll transverse joints must be picked up. As paving operations are continually moving, housekeeping muse be done to prevent running back and forth to pick up debris.

Hand tools can be kept clean by dipping them in solvent before placing them in the mix. After shovels or lutes are heated up by the mix they will stay fairly clean. If build-up of mix occurs, putty knives can be used to scrape the tools clean when the mix is still warm. When tools coated with asphalt mix get cold and cannot be scraped clean a torch should be used to heat them until the mix can be removed with a scraper. Be careful not to heat aluminum lutes too much as they will warp. After cleaning, tools should be coated with solvent for storage.

The paver should be thoroughly cleaned and washed down at the end of each day's paving while the machine is still warm. All the asphalt mix must be cleaned off the paver to prevent build up and maintenance problems. Carefully clean the hopper, the feeder chains, and the augers. After removing all the unused mix spray all contact areas with solvent to prevent mix from sticking when paving operations resume.

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Glossary of Terms

Aggregate	Various hard, inert materials such as sand, gravel, pebbles, etc, used as the bulk material in asphaltic mixes.
Angle of Attack	The angle included between the screed plate and the surface.
Asphalt	A mixture of bitumen (bonding agent) and aggregate (bulk material).
Auger	A rotating device with a broad, helical flange (flighting) used to spread paving material evenly in front of the screed.
Auger Shadows	Alternate dark and light areas of compaction occurring longitudinally in the mat representing different density and texture.
Automatic Feed Controls	The standard Blaw-Knox system for maintaining a constant head of material in front of the screed by controllin the ON - OFF operation of the unit's dual feed system.
Automatic Grade and Slope Controls	See Blaw-Kontrols.
Automatic Level Control (Joint Matcher)	An electric/hydraulic control system that automatically controls the elevation of the mat being placed on one side with respect to a reference surface such as an adjacent mat or cut. It is used to match the profile of the edge of a mat to that of the adjacent surface. (Not to be confused with the Blaw-Kontrol.)
Blaw-Kontrols (Automatic Grade & Slope Controls)	The Blaw-Knox electrictronic/hydraulic control system that automatically maintains the elevation of one screed tow point with respect to a reference surface (grade), while maintaining the elevation of the opposite screed tow point in relation to the first with respect to gravity (slope). It is used to improve upon the levelability of the paver.
Bitumen	A thick, viscous, petroleum-based substance used as bonding agent in asphaltic mixes.
Burners	See Screed Heaters.
Compaction	The process of increasing the density of paving materials.
Conveyor	An endless chain and bar assembly used to move paving material from the hopper to the auger.
Cross Beam	A steel bar connected between the side arms for mounting the slope sensor.
Crown	The transverse contour of a finished mat. Also used to describe the contour of the screed plate. The transition line between 2 different slopes (i.e., between lanes or between lanes and shoulders).
Lead Crown	The contour or profile from side to side of the leading edge of the screed.

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Tail (or Road Crown)	The contour of the trailing edge of the screed.
Negative Crown	Contour which is higher at the center than at the edges of a mat.
Positive Crown	Contour which is higher at the center than at the edges of a mat.
Cut-Off Shoe	A detachable plate used to reduce the paving width of a screed.
Density	Compactness of paving material.
Depth Crank	Adjusting crank located at the rear of each side arm, used to control angle of attack of the screed.
Edger Plate	A vertical plate at each end of the screed used to confine the head of material.
Elevation	Vertical height from a reference surface.
Feeders	L. H. and R. H. auger-conveyor systems on a paving machine.
Floating Beam	An aluminum beam, supported by a series of spring loaded shoes, towed beside the paver and used as a reference for Blaw-Kontrol or Joint Matcher systems.
Flow Gates	Adjustable plates at the rear of the hopper used to control material volume conveyed to the augers.
Floor Plate	A heavy steel plate upon which the conveyors travel.
Grade	1) The base surface (road bed) over which paving is being performed. 2) The elevation of a fresh mat in relation to the base. 3) The incline of a paving surface in the direction of travel, expressed by stating the rise or fall as a percentage of horizontal distance. (Example: 6% grade - 6' of elevation change in 100' of horizontal longitudinal run.)
Grade Control	A means of controlling the longitudinal elevation of a mat as it is being laid.
Grade Sensor	An electrical device which detects positive and negative changes in longitudinal elevation from a grade reference (i.e., wire, or stringline, floating beam, mat reference, adjacent mat or curb surface).
Head of Material	The volume of paving material directly in front of and along the entire lateral length of the screed.
Hopper	The area at the front of the paving machine which receives the paving material.
Hydraulic	Liquid in motion under pressure, the flow of which causes work to be accomplished.

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Hydrostatic Transmission	Power transmitted by a positive displacement pump through a liquid under pressure to a positive displacement motor.
Inclinometer	See Slope Sensor
Joint	The lateral point at which a new asphalt mat connects with one previously laid.
Lateral or Transverse Joint	A joint perpendicular to the direction of travel (i.e., night joint).
Longitudinal Joint	A joint parallel to the direction of travel (i.e., a joint between two "lanes" or between road and shoulder).
Transverse Joint	A joint perpendicular to the direction of travel.
Joint Matcher	See Automatic Level Control.
Lift	Another term for "mat", usually used in conjunction with a thickness, such as "a six-inch mat was laid in (3) two-inch lifts".
Line of Shear	The lateral line of contact in the paving material at the leading edge of the screed pre-strike-off where material divides to pass beneath the screed plate or move upward along the face of the screed into the augered material for later placement.
Mat	The material being placed by a paver/finisher.
Mat-Kontrol	The optional Blaw-Knox system for maintaining a constant head of material in front of the screed by controlling both the speed and ON-OFF operation of the unit's dual feed system.
Mat Reference System	An aluminum beam, supported by a series of spring loaded road wheels which is towed behind the screed. It is used in conjunction with the Floating Beam to permit taking 50% of the longitudinal grade reference from the freshly laid mat and combining it with the average taken from the existing grade to produce the ultimate in a smooth riding surface.
Null	A condition which exists when components are at rest.
"Nulled" Screed	A screed resting flat on the mat and having no angle of attack.
"Nulled" Grade & Slope Sensor	Sensors that are operating, however, they are transmitting not signal.
Paddle Box	The sensing device used with automatic feed control or mat-kontrol to measure and control the head of material.
Pull Points	See Tow Points
Push Roller	Rollers mounted at the front of the paver to provide contact area between the paver and the asphalt truck tires.

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Pre-Strike-Off Shield	The vertical plate at the front of the screed which meters material passing beneath the screed.
Quarter Points	Points on the screed midway between the center and the ends.
Ripples	Short frequent changes in the elevation of a mat surface.
Screed	The assembly towed behind the tractor, that strikes off, smooths and exerts some pre-compaction on the paving material being placed.
Screed Extensions	Attachments for increasing screed width.
Screed Heaters (Burners)	The devices which preheat the screed plate to a temperature approximately that of the material to be laid.
Screed Plate	The bottom plate of the screed.
Slope	The incline of a paving surface perpendicular to the direction of travel expressed by stating the rise or fall as a percentage of horizontal distance. (Example: 2% slope - 2" of elevation change in 100" of lateral run.)
Slope Control	A means for controlling the transverse elevation of the fresh laid mat in relation to the grade.
Slope Sensor (Inclinometer)	An electrical device which detects positive and negative changes in lateral elevation using the grade controlled side of the machine as a reference.
Tow Points (Pull Points)	The points where the side arms of the screed are attached to the tractor unit.
Vibrators	A rotating shaft and eccentric weight assembly mounted on the screed that produces vibration.
Wave	Long repeating changes in the elevation of the mat surface.

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Aging Asphalt Mat Blemishes and Causes

Cracks		
	Alligator	Cross-cross cracks usually due to heavy traffic loads exceeding the strength of the surface over an unstable base.
	Longitudinal	Cracks which appear along longitudinal joints, between lanes and shoulders and many times at the base and outer edges of ruts. These cracks result from movement along these weakened areas.
	Reflection	Existing cracks in sub-pavement eventually coming through an overlayment due to continues movement in the unstabilized sub-pavement.
	Shrinkage	Random cracks appearing due to lack of traffic which would normally keep the surface sealed.
	Slippage	Cracks appearing in the overlayment because the surface is pushed or rolled apart by breaking traffic. This may also occur if an overlayment is poorly bonded to the sub-pavement due to inadequate tack coating or improper mix design.
	Transverse	Cracks perpendicular to traffic flow. In overlays of concrete, the concrete joints may reflect thru surface if movement occurs along the joint. Concrete stress cracks across the pavement may also reflect thru.
Corrugation		Wash board effect usually occurring in areas where braking and acceleration take place. It may also occur to a lesser degree in the even speed areas. It is caused by an excessively soft mix over an unstable base.
Pot Holes		Local base failure causes a pocket which further deteriorates due to containment of water as the surface collapses. Traffic bounces the broken surface out exposing intermediate and base materials to more moisture and the abrasion of traffic.
Raveling		Road surface chunks away producing a very rough riding surface. Edges of pavement may completely disintegrate. The causes are usually the same as stripping but also may include deficient mix design.
Ruts		Troughs in the wheel tracks caused by increased compaction and/or stripping due to heavy traffic.
Shoving Bulge		Pavement which has been pushed by braking vehicles or roller.
Stripping		Road surface peels away producing a rough, open texture. It is usually due to debonding between the asphalt and aggregate. The cause may be heavy traffic and moisture or lack of density (full spec. compaction) when placed.
Upheaval		Swelling of sub-pavement caused by excessive heat or freezing expansion of trapped water beneath the surface.

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